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Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant(s):

UNIVERSITY OF WESTERN SYDNEY

and

ONESTEEL REINFORCING PTY LTD

Invention Title:

A REINFORCING COMPONENT

The invention is described in the following statement:

A REINFORCING COMPONENT

The present invention relates to a reinforcing component for a composite element for the building industry and to a composite element which incorporates the reinforcing component.

The present invention relates particularly to a reinforcing component for preventing longitudinal shear failure of the composite element.

The term "composite element" is understood herein to mean a beam, preferably but not necessarily formed from steel, and a solid or composite slab that are interconnected by shear connections to act together to resist action effects as a single structural member.

The term "shear connection" is understood herein to mean an interconnection between a beam and a solid or composite slab which enables the beam and the slab to act together as a single structural member.

In conventional composite elements, typically, the shear connection includes: (a) shear connectors, such as studs or reinforcing bar ligatures or structural bolts or channels, (b) slab concrete, and (c) transverse reinforcement.

The term "shear connector" is understood herein to mean a mechanical device such as a stud attached to a beam which forms part of the shear connection.

In particular, the present invention relates to composite elements of the type that includes the following components:

(a) a horizontal beam (typically but not

necessarily steel) supported at each end;

(b) a composite slab positioned on and supported by the beam and including:

(i) sheeting, preferably profiled (typically but not necessarily steel) ;

(ii) concrete cast on the sheeting; and

(iii) reinforcement embedded in the concrete; and

(c) a plurality of shear connectors, typically in the form of headed studs, embedded in the concrete and extending through the sheeting or adjacent to the ends or sides of the sheeting and connected to the beam thereby to connect the composite slab to the beam.

The present invention is concerned with reinforcing the type of composite element described above so that the composite element has sufficient shear capacity at the interface between the beam and the slab of the composite element to accommodate forces arising from compressive or tensile stresses caused by flexure of the beam to prevent premature shear failure (hereinafter referred to as "longitudinal shear failure") of the composite element.

The conventional reinforcement for preventing longitudinal shear failure in the type of composite element described above includes deformed reinforcing bars or welded wire fabric embedded in a horizontal position in the concrete of composite slabs. These reinforcing components are typically arranged to extend transversely to the longitudinal axis of the beam and therefore cross potential

longitudinal shear failure surfaces and by this mechanism are known to contribute to the longitudinal shear capacity of composite elements.

An object of the present invention is to provide a reinforcing component for preventing longitudinal shear failure of a composite element which is an alternative to and has advantages over the conventional reinforcement described in the preceding paragraph.

According to the present invention there is provided a reinforcing component for preventing longitudinal shear failure of a composite element for the building industry, which shear reinforcing component is an elongate member, such as a rod or a bar, that has been bent into a waveform configuration.

The waveform configuration may be any suitable form.

For example, the waveform configuration may be a square wave or a V-shaped, i.e. zig-zag, wave with short straight sections between the bends in the reinforcing member.

By way of further example, the waveform configuration may be generally sinusoidal.

The above-described reinforcing component can be located conveniently in the construction of a composite element to cross potential longitudinal shear failure surfaces and thereby contribute to the longitudinal shear capacity of the composite element.

In a situation in which the composite element includes a horizontal beam and profiled sheeting that has pans separated by parallel ribs with the ribs transverse to

the longitudinal axis of the beam, the reinforcing component can be positioned (prior to pouring concrete onto the sheeting to complete construction of the composite element) to rest on the ribs so as to extend along the line of the shear connectors connected to the beam.

The present invention is not confined to use with composite elements that include horizontal beams and profiled sheeting positioned so that the ribs are transverse to the longitudinal axis of the beams and can be used with composite elements in which the profiled sheeting is positioned with the ribs at any angle to the longitudinal axis of the beams.

Preferably the reinforcing member is a deformed bar.

Preferably the reinforcing member is a deformed steel bar having a yield stress of at least 400MPa.

More preferably the reinforcing member is a deformed steel bar having a yield stress of at least 500 MPa.

According to the present invention there is also provided a composite element which includes:

(a) a beam;

(b) a composite slab positioned on the beam, the composite slab including:

(i) sheeting;

(ii) concrete cast on the sheeting;

(c) a plurality of shear connectors which

connect the composite slab to the beam; and

(d) a shear reinforcing component for preventing longitudinal shear failure embedded in the concrete slab, the reinforcing component being an elongate member, such as a rod or a bar, that has been bent into a waveform configuration and located to cross potential longitudinal shear failure surfaces and thereby contribute to the longitudinal shear capacity of the composite element.

Preferably the sheeting is profiled and has a plurality of pans separated by parallel ribs.

The sheeting may be positioned so that the ribs are parallel to or transverse to the longitudinal axis of the beam.

In a situation where the composite element includes a horizontal beam and profiled sheeting that has pans separated by parallel ribs with the ribs transverse to the longitudinal axis of the beam, preferably the reinforcing component is positioned to rest on the ribs so as to extend along the line of the shear connectors connected to the beam.

Preferably the reinforcing component is fully anchored on both sides where it passes through a potential longitudinal shear failure surface.

Preferably the reinforcement member is embedded in the slab below upper ends of the shear connectors.

Preferably the beam is a steel beam.

Preferably the beam is supported at each end.

In one embodiment, it is preferred that the beam be an internal beam.

In another embodiment, it is preferred that the beam be a perimeter or edge beam.

It is preferred that the shear connectors be headed studs.

The shear connectors may be of any other suitable form such as structural bolts or channels.

The present invention is described further by way of example with reference to the accompanying drawings in which:

Figure 1 is a perspective view which illustrates a conventional composite steel-framed building construction;

Figure 2 is a series of perspective views and transverse cross-sections that illustrate Type 1, 2, and 3 longitudinal shear failure surfaces; and

Figure 3 is a top plan view of a composite element, in simplified form, which illustrates four embodiments of a reinforcing component in accordance with the present invention.

The reinforcing component of the present invention is suitable particularly for providing so-called "transverse reinforcement" for preventing certain types of longitudinal shear failure when conventional welded-stud shear connectors are used with profiled steel sheets incorporating ribs separated by pans laid at any angle to

supporting horizontal steel beams in the construction of steel framed buildings.

Figure 1 illustrates a conventional construction of a steel framed building.

With reference to Figure 1, the steel framed building is a composite element that includes:

(a) an array of horizontally extending intersecting hot-rolled or fabricated steel beams 5 supported at each end;

(b) a composite slab including:

(i) profiled steel sheeting 7 in contact with top flanges of the steel beams 5, the sheeting 7 including a plurality of parallel steel ribs 11 separated by pans 13; and

(ii) concrete cast on the sheeting 7;

(c) a plurality of shear connectors in the form of headed studs 15 which extend through the sheeting 7 and are welded to the top flanges of the beams 5; and

(d) conventional longitudinal shear reinforcing component in the form of a horizontally disposed mesh embedded in the concrete slab for preventing premature longitudinal shear failure of the composite element.

The composite element may be of any suitable dimensions and construction. Typically, the composite slab has an overall thickness of at least 120mm. In addition,

the ribs of the sheeting 7 can have a dovetail profile, a trapezoidal profile or a profile of any other suitable shape.

The reinforcing component of the present invention is suitable particularly for providing longitudinal shear reinforcement for Type 1, 2 and 3 longitudinal shear failure surfaces as defined in Australian Standard AS 2327.1. These shear failure surfaces are illustrated in Figure 2.

Figure 3 illustrates in diagrammatic form 4 embodiments of a reinforcing component in accordance with the present invention.

Each of the embodiments includes a steel bar 19a, 19b, 19c, 19d that has been bent into a zig-zag waveform configuration and is positioned to extend along a line of shear connectors 15.

In the case of the reinforcing components 19a, 19c the wavelength of the zig-zag waveform is such that the reinforcing components fit between and do not clash with the shear connectors 15 and the reinforcing components 19a, 19c sit on top of the ribs (not shown) of the underlying profiled steel sheeting.

However, depending on the shear connector spacing and the wavelength of the reinforcing components, the zig-zag waveform reinforcing components may clash with the shear connectors 15 when they are placed on site, noting that normal practice is to place the shear connectors 15 first.

Depending on the circumstances, there may be less clash with shear connectors 15 if different shaped waveforms, such as square or sinusoidal shaped waveform

reinforcing components (not shown) were used.

In particular, it is noted that square waveform reinforcing components may have alternating short and long outer edges, so that transverse bars can effectively be positioned in pairs if desired, for example to concentrate bars between adjacent shear connectors 15 when the longitudinal shear forces are high, small diameter bars are used for improved anchoring efficiency, and/or to reduce the chance of the bars conflicting with the shear connectors 15.

The reinforcing component of the present invention can be manufactured at comparatively low cost using very rapid bar-bending equipment to form waveform bars of almost any conceivable shape.

The reinforcing component of the present invention can be made to any length subject to handling and transport restrictions.

The reinforcing component of the present invention can be anchored highly efficiently, and typically the distance between the outer edges of the waves and the line of shear connectors 15 that is required to anchor the component fully is about half that of straight bars.

Preferably the reinforcing component of the present invention is fully anchored on both sides of a potential longitudinal shear failure surface where it crosses the surface so that it can develop its full tensile capacity when there is relative longitudinal movement between the adjacent concrete surfaces on opposite sides of a failure crack. By being able to develop its tensile capacity, the reinforcement restricts the width of a crack and creates a clamping force across the sliding surfaces. Aggregate interlock and frictional resistance develop which

resist the longitudinal shear.

In AS 2327.1, the nominal longitudinal shear capacity per unit length of beam (V_L) of a Type 1, 2 or 3 shear longitudinal shear failure surface is assumed to equal:

$$V_L = 0.36\ \mu\sqrt{f'_c} + 0.9A_{sv}F_{SY}$$

The first term in the above equation basically accounts for the resistance due to aggregate interlock. The second term in the equation can be thought of as a frictional clamping term with the design coefficient of friction between the sliding concrete surfaces equal to 0.9. Using this equation the reinforcement is assumed to be at 90 degrees to the sliding surfaces or crack.

If the reinforcement is at an acute angle θ to the sliding surfaces, then the equation for V_L becomes:

$$V_L = 0.36\ \mu\sqrt{f'_c} + 0.9A_{sv}\sin\theta$$

whereby the effectiveness of the reinforcement is reduced as a function of sin θ.

Different factors will determine if a zig-zag waveform reinforcing component of the present invention is more cost efficient than a square or other shape waveform reinforcing component of the present invention for a given situation.

Normally, it will be preferable to optimise the amount of material used, while limiting the chance of the reinforcement clashing with the shear connectors 15 on site.

It is also preferable that the bars do not flop

over when resting on the steel sheeting ribs (e.g. if square waveform bars are used that have the same pitch as the steel decking pans) and that the bars be sufficiently strong to be handled on site and to support light foot traffic without being permanently deformed out of plane.

Multiple rows of shear connectors 15 may be used and they may also be staggered.

Shear connector spacing may vary along a composite beam, but is normally stepped keeping the spacing constant within each step. It is common that shear connectors 15 will be more closely spaced towards the ends of beams. With prior knowledge of the shear connector spacings, the pitch along the waveform reinforcements can be varied as necessary during manufacture.

Many modifications may be made to the preferred embodiment of the reinforcing component and the composite element shown in the figures without departing from the spirit and scope of the present invention.

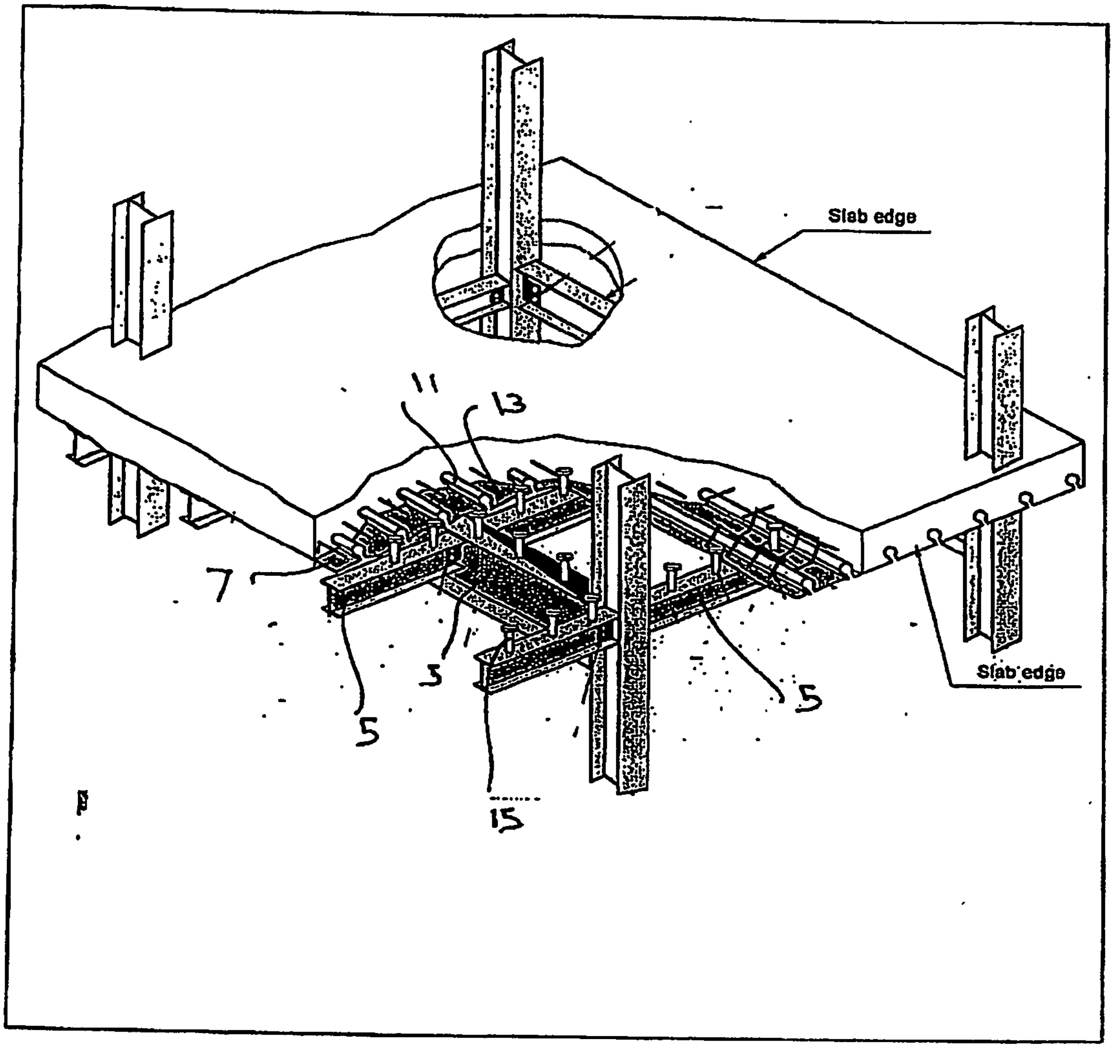
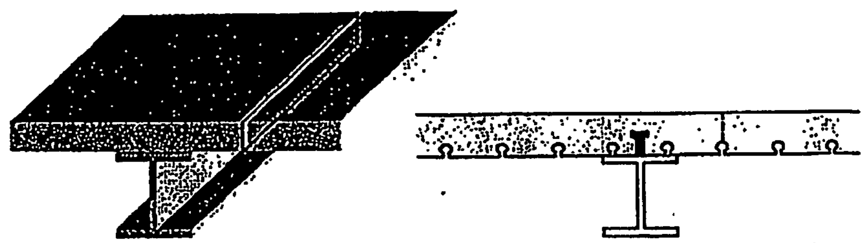


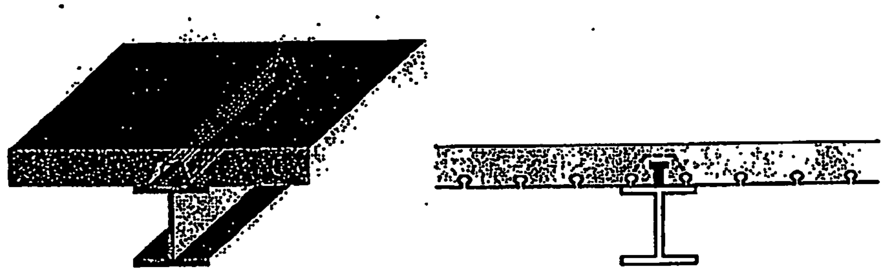
Fig. 1 Conventional composite steel-framed building construction

Figure 2



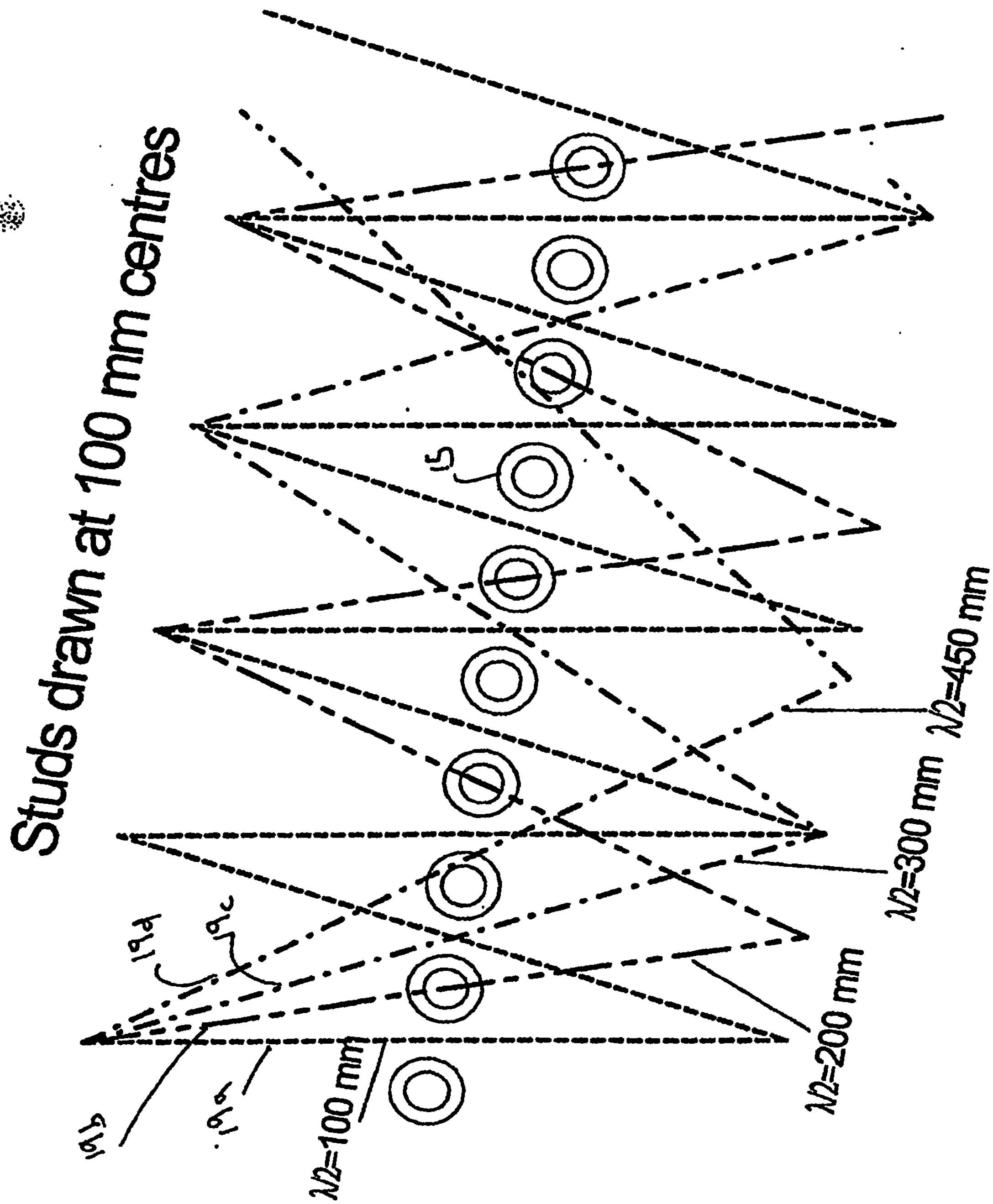
(a) Type 1

(b) Type 2



(c) Type 3

Figure 3



Studs drawn at 100 mm centres
15
19a
19b
19c
19d
λ/2=100 mm
λ/2=200 mm
λ/2=300 mm
λ/2=450 mm